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DEVELOPMENT OF MULTI-NUTS POST HARVESTING (MNPH) MECHANISM BY COMPUTER AIDED ENGINEERING ANALYSIS

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ABSTRACT

The Present research work introduces a flexible multi-nuts Shelling, Cutting, Slicing, Squeezing, Cracking and De- hulling Mechanisms like operations by just exchanging an operative tool and raw material fixture set .The different types of nuts such as marking-nuts, walnuts, almond and areca-nuts were considered for the post harvesting operation by using the same working platform in vertical cut plane. The Computer Aided Engineering Analysis (CAE) by finite element analysis to perform a simulation for optimization MNPH Machine is done by considering an actual field condition parameters to do the structural analysis. Sum of the reaction forces along X-axis:38482 N, Y–axis:-3641N, Z-axis: 20757.5N.The structural analysis of the mechanism shows all components in the mechanism are in safe limit for all types of forces exerting during operations. The average product material efficiency for marking nut, walnut, almond, areca was 87.22%, 72.23%., 85.29%, 95.00%.The operational time 0.4hrs to 1.5hr for 100 pieces of all selected nuts whereas, average mechanical damage 12.78,28.00, 14.71%, 5% and Throughput capacity: 0.60, 2.5,0.60,1 Kg/hr respectively. Machine cost with optimum design and fair material selection is approx. $50.

KEYWORDS: Multi-Nuts Mechanism, CAE, Walnut, Almond, Areca, Marking Nut

INTRODUCTION

The nut cracking is an old practice of post-harvest operation. The traditional mechanism available in the market needs to be optimistically re-designed to improve an efficiency and also for the human comforts. The present study of a “Multi-Nut Post-Harvesting Mechanism” is done by computer aided engineering analysis and optimization techniques.

The various researcher’s practices focused nuts cracking mechanism in the horizontal plane and single type of nuts shelling /cracking process , however the proposed research work considers the vertical cut plane with flexible mechanism such that various types of nuts or horticultural fruits can be harvested. The design and fabrication of M.N.D. Machine is done by preparing a conceptual CAD-solid model with preparation of different parts and their assembly and FEA meshing for its structural analysis using CAD software to confine the specifications of different parts of machine.

MATERIALS AND METHODS

In traditional method workers break the pericarp by biting with stone and separate kernels. Also during de-hulling by stone hammering most of the seed kernels becomes blackish so their market value decreases. The breaking of marking nut is very tedious, laborious and time consuming in traditional method. There were some dehuller like curved blade type dehuller, notch type dehuller, shell and blade type dehuller, hold and press type dehuller designed by other researchers.

However, the proposed research work adopted to present a quality product of multi nut post harvesting mechanism which is outlined in the CAD/CAM laboratory of College of Agril.Engg & Technology, Marathwada Agricultural University campus, Parbhani (M.S.) India. The evaluation procedure for the dehuller is also been discussed.

Design Consideration

Following points were considered in the design of MNPH-Processing Unit Mechanism.

- Separation of kernel without or with less damage in cracking.
- More than one kind of nuts for their cutting, slicing, cracking, squeezing, shelling and DE hulling like operations separate processing tools are designed to operate in single mechanism.
- Prevention of splashing during cracking on the facing body parts of the workers.
- Minimization of efforts of the workers in cracking.

The physical dimensions of nuts derived for designing the cutting tool geometry specification to be fixed in vertical cut plane mechanism as mentioned below in Table 1.

Table 1: Physical Dimensions for Cutting Tool Geometry Design Specifications

NUTS	Physical Dimensions	Operation Type / Force
Marking Nut	H=18.94 to 26.45 mm W=15.74 to 18.70 mm t =1.86 to 2.78 mm m=2.36 to 2.57 gm	Cutting + Cracking
Walnut	H= 34.25 to 40.80mm W=27.58 to 32.50 mm t=2.80 to 3.41 mm m= 9.13 to 13.27 gm.	Cracking +Shelling
Almond Nut	H=34.25 to 40.80 mm W=27.58 to 32.15 mm t=2.82 to 3.41 mm m=9.13 to 13.27 gm.	Cracking +Shelling
Areca Nut	L=20.98 to 22.87mm W=29.49 to 30.23mm ; m=14.78 to 16.45 gm	Cutting +slicing
Aonla	D =40.7 mm D(seed)=15 mm m=35 gm	Cutting + slicing
Mango	H=Range 4 -10mm W= Range 3 - 6mm H(seed)= Range 2– 6 mm W(seed)= Range 2– 4mm	Cutting +slicing

Computational Tool Application in Design Analysis

CAD Solid Model & CAE-simulation in Software environment is done by FEM analysis for all component. It is feature based modeling.

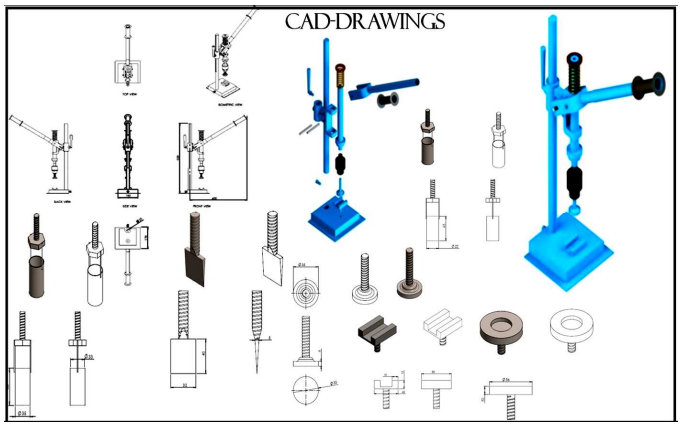

Figure 1: Cutting Tool Design & Drawings for MNPH Machine

Table 2: MNPH-Machine Component's Specifications

Name of the part		Shape	Length, mm	Width mm	Height mm	Thickness mm	Diameter, mm
Guide way column		Cylindrical	--	--	500.0	--	25.0
Press lever		Cylindrical	330.0	--	--	2.8	27.5
C-clamp		C-shape	98.0	69.2	32.40	16.0	--
Base fixture stand	Flat rectangular	Rectangular	71.0	40.4	5.2	--	--
	Strip supported	Rectangular	71.0	40.4	5.2	--	--
	Circular with notch	Circular	--	--	--	9.8	45.0
Base Plate		Circular	--	--	41.2	10.6	154.0
Punch		Circular disc				9.0	32.0
Cutter		Rectangular	62.7	30.2	--	6.6	--
Axle		Cylindrical	23.0	--	--	--	26.12
Chuck		Cylindrical	--	--	55.3	--	42.0
Fixture bracket		-	--	45.2	109.2	--	--
Compression spring		Helical	91.1			3.3	34.0

The computer aided drafting for all machine components are mentioned in figure 1 and their specifications shown in the Table 2. The hollow cutters for aonla are designed according to seed diameter and different knife edge cutters for slicing a fruits and nuts according to physical dimensions.

The structural analysis of the assembled machine with all field parameters such as operational force, work material properties and structural strength considered during computer aided simulation to obtain a stress distribution amongst all components. The iterative simulation done to introduce a CAE-cycle for reverse engineering process. The CAE-cycle for design optimization is mentioned in figure 2.The maximum stress after simulation cycle reported in post processer at respective node in Finite mesh are corrected with necessary modifications in design or geometric configurations. The cycle is repeated till final confirmation in deriving fabrication parameter by reporting all components in assembly in structural safe limit.

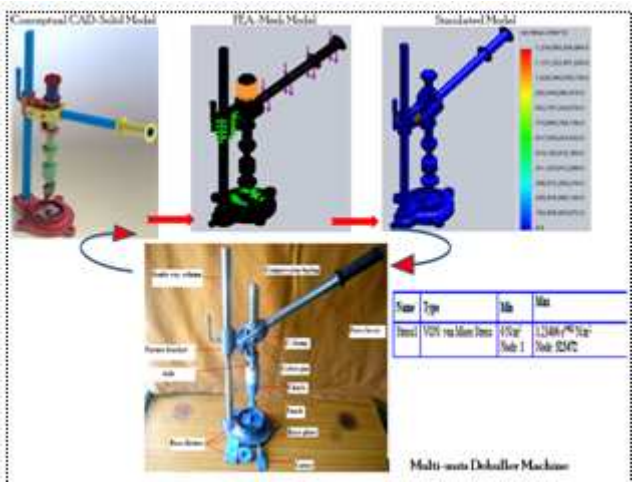

Figure 2: CAE-Cycle for MNPH Machine

The manufacturing process flow chart for specific operations are mentioned in figure 3 below for fabrication cycle of MNPH Machine.

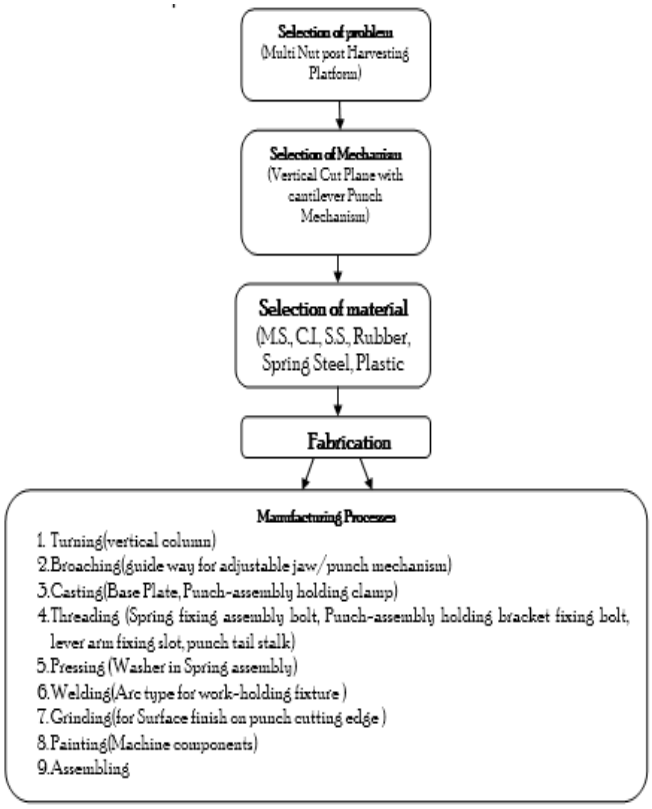

Figure 3: Manufacturing Process Flow Chart of MNPH

Performance Testing of Machine

The efficiency of the machine with the manual method for marking nut dehulling, three different methods of hulling were adopted for the test. These were traditional dehulling, dehulling using notch type dehuller, and dehulling using curved blade type dehuller. The results of selected 100 pieces of markingnut,walnut, almond and areca nuts seen in image below figure 4 after random tools and nuts operations on the same platform.

The following were the measurements taken before and after the hulling operation using the fabricated machine: Total weight of marking nut used; weight of marking nut hulled; weight of kernels obtained; weight of whole kernel obtained and shelling time.

Test Parameters

Some test parameters, such as throughput capacity (kg/h), shelling efficiency (%), Product material efficiency (%) and mechanical damage (%), in Multi nut dehuller, can be applied in testing a sheller as follows:

Throughput capacity (kg/h) = Q_s / T_m---------- (1)

Shelling efficiency (%) = (Q_s / Q_t) x 100---------- (2)

Product material efficiency(%) = (Q_u / (Q_u +Q_d)) x100 ------- (3)

Mechanical damage (%) = (Q_d / (Q_u+Q_d)) x 100 -------- (4)

Where: Q_t = total weight of shelled & unshelled nuts (kg)

T_m= time of shelling operation (h) ; Q_s= quantity of shelled nuts (kg).

Q_u= quantity of undamaged nuts (kg).; Q_d= quantity of damaged nuts (kg)

RESULTS

Table 3: MNPH Machine Performance & Product Quality

Material	Average Operational Time For 100 Pieces (Hrs)	Product Material Efficiency (%)	Shelling Efficiency (%)	Mechanical Damage (%)	Throughput Capacity (Kg/Hr)
Marking nut	**0.40**	**87.22**	**97**	**12.78**	**0.60**
Almond	**0.40**	**85.29**	**96.75**	**14.71**	**0.60**
Walnut	**0.40**	**72.00**	**96.81**	**28.00**	**2.00**
Areca nut	**0.50**	**100.00**	**-----**	**-----**	**1.00**
Aonla	**0.30**	**98.00**	**-----**	**02.00**	**1.25**
Mango	**0.25**	**100.00**	**-----**	**------**	**1.50**

Figure 4: Performance Test of MNPH Machine

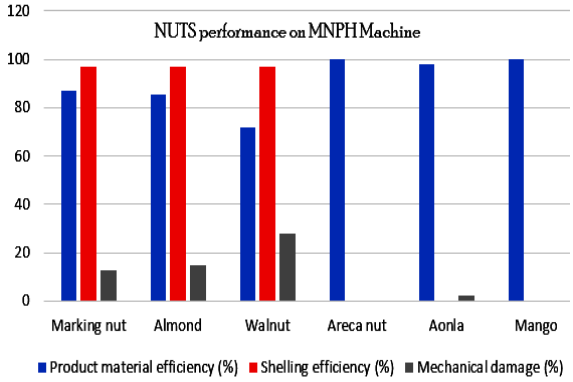

Figure 5: MNPH Machine Performance & Product's Quality

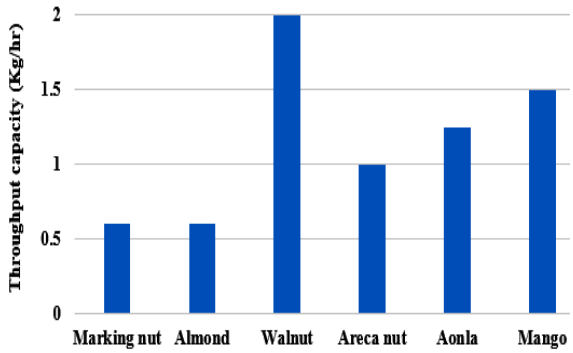

Figure 6: Throughput Capacity (Kg/Hr) of MNPH Machine

The average Product material efficiency of Multi nut post harvesting machine from figure.5, it is observed that the areca nut, aonla and mango were efficiently rated in product quality and from figure 6.

CONCLUSIONS

The Computer Aided Engineering Analysis (CAE) by Finite Element Method to perform a simulation for optimization MNPH Machine is done by considering an actual field condition parameters to do the structural analysis.

The sum of the forces in the structural simulation along X-axis:**38482**N, Y–axis:**-3641N**, Z-axis: **20757.5**N was observed.

It is observed that throughput capacity (Kg/hr) of walnut, areca nut, aonla and mango was ranging from 1-2kg/hr.

The cutting tools with accessories in MNPH machine for processing operations are easier to exchange.

The Cost of modified machine is $50.00(INR 3000)

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